

submitted in February 2005. The results of the study are summarised in the following sections.

5.4.2 Bathymetric Survey and Sub bottom Profiling

NIOT has carried out Geophysical survey using Sparker & Boomer seismic system and parametric sub bottom profiling along the alignment of the channel to assess the nature of subsurface below the sea bed and for confirming the selected alignment which starts from 5 km south of Adam's Bridge and runs through Palk Bay and Palk Strait areas to meet the Bay of Bengal opposite to Point Calimere. The penetration obtained from the above systems was of the order of 40m below sea bed with 70m penetration reported at places. Bathymetry data was also simultaneously acquired using a ODOM Echo track dual frequency echo sounder. The overall alignment of the proposed channel has been divided into six segments, namely GA(4.32km), AB(17.26km) & BC(13.33km) all in Adam's Bridge area, CD(37.58km) & DE(40.74km) both in Palk Bay area and EE4(54.33km) in Palk Strait area. Of these the Palk Bay area is of natural depth greater than 12m.

The surveys were carried out for a corridor width of 500m on both sides of centre line of proposed alignment at a spacing of 150m apart consisting of 8 survey lines including the centre line. The surveys were carried out by coastal research vessel, CRV Sagar Paschmi during 6th to 23rd November '04 and during 16th to 17th December '04 and have run through a total of 1379 km length of survey lines. The survey vessel was accurately positioned using Leica DGPS with RTCM corrections from 'OMNISTAR'.

In order to apply tidal corrections NIOT had installed 3 tidal stations at Nagapattinam, Pamban Pass and Sethubavachatram and tides were measured for a total of 30 days. The tidal field in this area was found to be complicated and was influenced by

- (i) south bound currents from Northern Bay of Bengal, north of Adam's Bridge,
- (ii) the tidal build up from south, ie from Gulf of Mannar, and
- (iii) the overall tidal effect from the Bay of Bengal from the east

Hence NIOT had carried out a Tidal Propagation model using MIKE 21, the out put of which was used to reduce the bathymetry to chart datum along various segments of the channel.

5.4.3 Geotechnical Investigations

5.4.3.1 Vibrocoreing

NIOT have carried out detailed Geo-technical investigations along the channel site during January – February, 2005 covering the entire alignment. NIOT carried out 44 Vibro-coring operations by deploying 6m long core lines with a specially designed 'A' Frame on board a survey vessel, Shiva-I. The vibrocore locations are as shown in Fig. FD0503.

The exact vibrocore location is fixed by DGPS, and the vibrocorer with a bottom stabiliser is raised to vertical position with the help of ropes and lowered into the sea. Once the instrument touches the sea bottom the current switch is activated which causes necessary vibration so that the core barrel penetrates sea bed and collected core is retained by core catcher.

The number of vibrocores, water depths encountered at vibrocore locations, core recovery in metres, segment wise are given in Table 5-3 below:

Table 5-3 Details of Vibrocore Investigations along the proposed channel

Segment	No. of vibrocores	Water depth	Core recovery	Remarks
AB	4	6.5 to 9.1m	0.5 to 1.8m	Medium to fine sand at top, hard sand at bottom
BC	6	8 to 12.12m	0 to 2.6m	Sandy strata, with sandy to clayey sand at top
CD	8	12.7 to 13.38m	1.1 to 2.35m	Softy clay at top, firm to stiff clay at depth
DE	11	12.5 to 13.5m	0.75 to 3.00m	Softy clay at top, firm to stiff clay at depth
EE4	13	7 to 12.10m	0.76 to 3.25m	Mostly clay, with calcareous stone encountered

All the cores collected were analysed by NIOT for their geotechnical properties, with some of samples tested for their calcium carbonate and organic contents, the details are given in Annexure A.5.1

5.4.3.2 Bore Hole Investigations

NIOT have conducted four marine boreholes so far at Adam's Bridge area in the land portions in scattered islands closer to the proposed alignment of channel. The diameter of boreholes are 100mm drilled with a casing pipe of 150mm done through rotary drilling method adopting double tube core barrel. The land level at these islands where boring has been conducted were reportedly 0.5m above sea level submerging at high tides corresponding to approximately +1.50mCD. The boreholes are numbered 1, 2, 4 & 11 and location of boreholes are as shown in Fig. FD0503.

NIOT is carrying out six additional boreholes along the Channel alignment to support and substantiate the data obtained from the boreholes in the scattered islands close to the alignment.

5.4.4 Discussion of Results

5.4.4.1 Bathymetry Survey

Section EE4: The total length of 57 km is covered in two blocks for convenience and appropriate tidal corrections. The deepest part of this section is 12 -13m, shoaling towards centre of alignment up to as low as 8m around coordinates 10° 8' N & 79° 56' E. It has been seen that there is an overall gentler shallowing of seabed in the middle portion with end parts deepening. The southern block of this alignment is about 10m deep and ending part is around 12.3m deep.

Section DE: This block is oriented NE to SW and has a uniform sea bed with minor undulations right from beginning to end. At the southern end of the block, the bathymetry is varying from 12 to 12.6m and at very few places, while depth less than 12m are observed at a few places to the north of the survey corridor. However, the depths to the south of the survey corridor are greater than 12.0m. Hence the alignment is shifted towards this side.

Section CD: In this section the bathymetry shows the terrain is flat and uniform section with bathymetry varying from 12 to 13m throughout. The line on the eastern side shows generally 13m depths.

Section BC: BC is oriented NNW to SSE. In this section shoaling starts from 12-13m depths in the northern end with 11m depth appearing upto 9° 18' 15"N. The western parts of this segment are shallower than the eastern part. The section ends up with depths around 9m.

Section AB: NIOT have terminated the bathymetry survey in this section at a distance of 7km from the point B in which distance the bathymetry reduces from 9m to 3m just north of the wave breaking zone/Adam's Bridge (as seen from the bathymetry chart). NIOT couldn't continue the survey in the wave breaking zone. However from latitude 9°6'N to 9°3'N the water depths is seen to be increasing from 2.2m to 15m.

The results of the bathymetry survey by NIOT are presented in Figures FD0504 - 0507.

5.4.4.2 Sub Bottom Profiling

The seismic sections collected along the transects are reported to be good and interpretable in nature. Several subsurface reflections are deciphered up to a depth of 30m below the sea floor. Based on the reflectivity the subsurface layers are designated as L1, L2, L3, L4 etc and they show good lateral continuity and probably represent clays to stiff clays, fine to medium sands and compact sand stones. The strata in between these reflective horizons, show few internal reflectors and are homogeneous and are suggestive of fine to medium grained sandy sediments with rocks, sand stones, pebbles and broken shells. The individual thickness of these beds varies from 1.0 to 4.0m in the area surveyed.

The seismic / sub bottom profiling is carried out only from a minimal depth of 9m and below and sub surface features have been obtained for depths ranging 18-20m below the sea bed. In that way, the subsurface features in the top depths between say -1.5 to -9m in sections AB and BC of the alignment could not be possible to be obtained by seismic profiling method.

The subsurface features in Sections AB and BC both in Adam's Bridge area and in Section EE4 of the Palk Strait for the central line of alignment and along the lines 150m on either side of central line thus covering 300m width of the proposed channel as extracted from NIOT's Report are drawn graphically and shown in Figures FD0508, 0509 and 0510.

The results for Sections CD and DE lying in Palk Bay since start at -13m greater than the proposed dredge depth of -12m, and hence not considered for depiction in this DPR.

5.4.4.3 Vibrocoring

Referring to Annexure A.5.1, the investigation results are discussed as below:

In the Section AB of Adam's Bridge area, since the penetration of vibrocorer and the core recovery are limited (only 0.5 to 1.8m) and the sea depths are shallower, the lithology/visual description of strata are seen to be limited to top layers which are described as loose, greyish silty sand followed by sandy layer mixed with pieces of clayey calcareous sand stones(AB2 and AB3) /shell pieces. This section contains even shallower depths ranging from -1.1m to -7.0m along the alignment of the channel for which the borehole investigations conducted closer to alignment have to be referred to.

In the Section BC of the Adam's Bridge area, the vibrocores are seen to be conducted at depths ranging from -8.0m to -12.1m and the core recovery is seen to be upto 2.83m(BC2). Here again the top layer is seen to be medium to fine sand, greyish, silty and clayey in nature, followed by firm clay / silty sand with shell or sand stone pieces.

The Sections CD and DE lie in Palk Bay area with natural depths greater than 12m and require practically no dredging for the planned dredge level of -12m. The vibro core results in these segments are of least significance for the current dredging. NIOT have conducted a total of 8 vibrocores in section CD with water level varying from 12.7 to 13.38m and 11 vibrocores in section DE with water level varying from 12.5 to 13.5m all greater than the dredge level of -12m.

In the Section EE4, the depths along channel alignment follows a gradual decreasing pattern from east to west for a particular length and west to east for a particular length. Starting from the point E the depth decreases from -11.9m to -7.5m along the middle and then increases to -11.2m at E4. A total of 13 vibrocores have been carried out in this segment with core recoveries varying from 0.76m to 3.25m. The geo-physical surveys conducted at points close by are referred to arrive at substrata particulars at such places. According to vibrocore surveys, the top layer in this (EE4) stretch is seen to be greyish loose soft clay for a smaller depth of about 0.20m, followed by about 0.75 to 1.0m deep similar silty clay(EE4-1, EE4-3a, 3b, 4 etc) with broken shells at some places(EE4-6) and in some places brownish silty fine to medium sand for 1.3m depth (EE4-7a, 7b, 10) followed by grey silty medium to fine sand. At the western end of segment EE4 (Palk Strait) where the alignment meets Bay of Bengal, in some of vibrocore locations (EE4-1, EE4-9 and EE4-13), cement colour clay with pieces of sand stone are reported to have been met with at depths 2m and above.

The vibrocore results show that the specific gravity of the soil strata is given to be varying from about 2.2 to 2.6 found from Specific Gravity (Pycnometer) tests. The vibrocore samples are found to be low in Calcium Carbonate (less than ~8%) and Organic Matter(normally less than 2%, one or two recording 6.88% and 12%).

5.4.4.4 Geotechnical boreholes

The borelog details up to the dredge level –12m are of relevance for the current dredging Project. All the boreholes are to a minimum depth of - 21m.

Borehole –1(Ref: Borelog shown in Figure FD0511)

The first 3m depth is of grey fine sand having N-value 9 to 12. Strata between 3 and 6m depth is of grey silty fine sand having N-value 13 to 41. Between 6 and 7.5m, greyish silty fine sand having N-value 51 is found. Between 7.5 and 10.5m depth, the N-value decreases to 19 and 24. Beyond 10.5 and upto 12m, the strata is found to contain crushed pieces of rocks and calcareous sand stone having greater N-values(50 blows for 60cm penetration). Between 12 and 13.5m, silty fine sand is reported with N-value dropping to 13.

Borehole – 2 (Ref:Borelog shown in Figure FD0512)

The first 1.5m depth is of fine sand having N-value 36. Between 1.5m and 6m, grey silty fine sand is encountered with N-value ranging from 46 to 56. Beyond 6m and upto 9m, the N-value is found increasing to 59 and dropping to 54. Beyond 9m and upto 12m the N-value decreases to 16-21 and beyond 12m, pieces of rocks and pebbles with calcareous sand stones have been found.

Borehole – 4 (Ref: Borelog shown in Figure FD0513)

The first 3m depth is of medium to fine grained grey-calcareous sand with N-value 16 and 22. Beyond 3m and up to 9m depth, the strata is seen to be medium to coarse sand with pieces of calcareous rocks with N-value increasing from 35 and ending with 76. Beyond 9m, upto 13.5m, soft layer is found to have N-values dropping to between 9 and 26.

Borehole – 11(Ref: Borelog shown in Figure FD 0514)

Here the first soil strata from 0 to 1.5m is seen to be fine to medium calcareous sand with N-value of 25. The next 1.5m, the layer is of coarse calcareous sand with N-value, 50. Further strata below, each of 1.5m thick are found to be having relatively lesser N-values 30, 41, 42 and 45 upto a depth of 9m. Beyond 9m, the layers become soft with N-values dropping to between 9 and 11 upto 13.5m beyond which the layers getting relatively stronger.

All the above four bores show similarity of substrata with comparable N-values, for dredge depth upto – 12mCD.

5.5 Hydrodynamic modelling Sedimentation studies and Ship Manoeuvring Study by Indomer - Alkyon (2005)

5.5.1 Background

Subsequent to the submission of the final DPR to TPT in November 2004, the results of the Hydrodynamic modelling study and Ship manoeuvring study carried out by M/s Indomer-Alkyon were made available by TPT to LTR. Final report was submitted in February 2005.